Gravina Access Project

Wind Climatology Technical Memorandum

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Prepared for:

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The objective of this climatology project is to provide joint probability wind speed and direction tables, an annual extreme value distribution with return periods, and monthly and annual wind statistics for the Ketchikan, Alaska area.

Data Sources

Hourly records of wind speed, wind direction and air temperature were purchased and analyzed for Ketchikan Airport. The data comes from the National Climatic Data Center (NCDC) in Ashville, NC. The source file is TD-9956, DATSAV3. Hourly data for the Ketchikan Airport is available for the years 1973 to 1998. Wind speeds are assumed to be the 1-minute average taken on the hour from 1973 to 9/1996. In December of 1996 the data collection was automated. The station is currently an ASOS (Automated Surface Observing System) station operated by the FAA. The ASOS standard for wind speed measurements is the 2-minute average taken during the 2 minutes before the hour. The ratio of the 1-minute average to the 2-minute average is 1.06. The 1.06 correction is the standard relationship contained in the USACE Shore Protection Manual. This correction factor has not been adjusted for the local duration-wind speed relationship described in the Results section. The 1.06 correction has been applied to the data subsequent to 9/1996. The automated anemometer is currently at 83', however the average elevation over the years of the data set appears to be 76'.

Statistics

The hourly record has been sorted to produce joint probability tables for wind speed and direction on a monthly and annual basis. The marginal cumulative probability distribution of wind speed is plotted on Weibull Type II probability paper with a variable k- parameter to produce a least squares straight line fit to the cumulative distribution. Interpolations for statistical levels of 50^{th}, 75^{th}, 90^{th}, 95^{th} and 99^{th} percentile are easily determined.

Results

A subset of the complete wind speed time series for the years 1990 to 1998 is plotted in Figure 1. Figure 2 shows a scatter plot giving the relationship of the observed 1-minute average wind speed to the simultaneously reported gust wind speed. The ratio of the gust wind speed to the 1-minute average is found to be approximately 1.52. This ratio is higher than the standard presented in the US Army Corps of Engineers Shore Protection Manual. The ratio assumed for most locations is 1.242. This indicates that Ketchikan has higher gust wind speeds in relationship to the average wind speeds than is expected at other locations. As described in the introduction, the relationship between the 1-minute average and the gust wind speed found from this data implies that the standard formula from the SPM for the relationship between 1 and 2 minute averages will also be different. However, we have no information on which to modify the SPM correlation.

The annualized joint probability table for wind speed and direction for all the data years is shown in Figure 3. The annual extreme value distribution is plotted in Figure 4. The annual cumulative distribution is shown in Figure 5. The annual extreme value distribution has been reviewed and adjusted as a result of a close inspection of the wind speed records. Several of the annual extremes previously identified were the result of invalid data. The invalid recordings were identified by inspection of the wind speeds recorded for the hours before and after the extreme.

The time of year was also be used as a guide. Several of the extreme values appear to have resulted from anemometer malfunction, passing birds or airplanes. This extreme value data check was not completed for the previous submittal. The cumulative distributions from which the annual and monthly statistics are derived are not effected by the elimination of a few errant extreme values. The Weibull plots of the cumulative probability of wind speed by month are shown in Figure 8 through Figure 19. The monthly wind speed statistics are given in Table 2.

The statistical and return wind speeds appear to be less than expected at this location. This is often the case when long time series wind speed measurements and professional observations are analyzed. The apparent bias that high winds are common can be attributed to; local geographic and architectural effects, the tendency of individuals to remember only to most severe cases and to the relationship between averaged wind speeds and gust wind speeds. Applying a multiplier of 1.52 to the return period and statistical level wind speeds changes one's perception of the severity of the conditions. Table 1 gives the annual statistics and return period winds for both the one-minute average and gust wind speed. The 95th percentile wind gust is 25.8 knots (29.7mph). The five-year return period wind gust is 65 knots (75 mph).

Wind at Proposed Bridge Site

One of the primary objectives of this wind climatology study was to define appropriate design wind speeds at the proposed bridge site. It was therefore necessary to estimate the relationship between wind characteristics at the anemometer site at Ketchikan Airport and at the bridge site, taking into account differences in surface roughness and height. A logarithmic profile is used to estimate the variation of wind speed as a function of height. The log profile at the anemometer site starts from the anemometer base elevation. The profile at the bridge site starts from MSL, 25.3 meters below the anemometer base.

Figure 6 and Figure 7 present the results of these transformations. The red lines on the plot show the difference between the 5-year return winds at the anemometer site and the bridge site as a function of height above the anemometer base. At 10 meter height, the 5-year return wind speed at the bridge site is expected to be about 8 knots higher than at the anemometer site. This is due to reduced surface roughness over water. However, at higher elevations, the effects of surface roughness become less important, and the speeds at the two locations converge. At 100 meter height, for instance, the expected 5-year return wind speed at the bridge site is only 1 knot higher than at the anemometer site.

Similarly, the yellow curves show expected 50-year wind speeds as a function of height for the two locations. They also converge at higher elevations.

The lashed dark line curve on Figure 6 and Figure 7 is the wind speed versus height as recommended by ASCE for design of buildings and other structures in coastal areas of Southeast Alaska. The gust speed is transformed to a one-minute average wind speed using the relationship found in the scatter diagram of Figure 2. The 3-second gust of 90 knots with a return period of 50 years is plotted in Figure 7. Winds at other elevations are estimated using category D exposure (overwater) from Table 6-3 of the ASCE Standard. ABS wind force versus height above water from the Rules for Building and Classing Mobile Offshore Drilling Units are also plotted.

The ASCE standards allow for wind speed adjustments when regional climatic data indicate that wind speeds are locally higher than those prescribed.

Table 1

Ketchikan Airport Wind Statistics	1-minute average (knots)	Gust wind speed (knots)	Gust wind speed (mph)
100 year return	63	96	110
50 year return	58	88	101
10 year return	47	71	82
5 year return	43	65	75
99th percentile	23	35	40
95th percentile	17	26	30
90th percentile	15	23	26
75th percentile	11	17	19
50th percentile	8	12	14

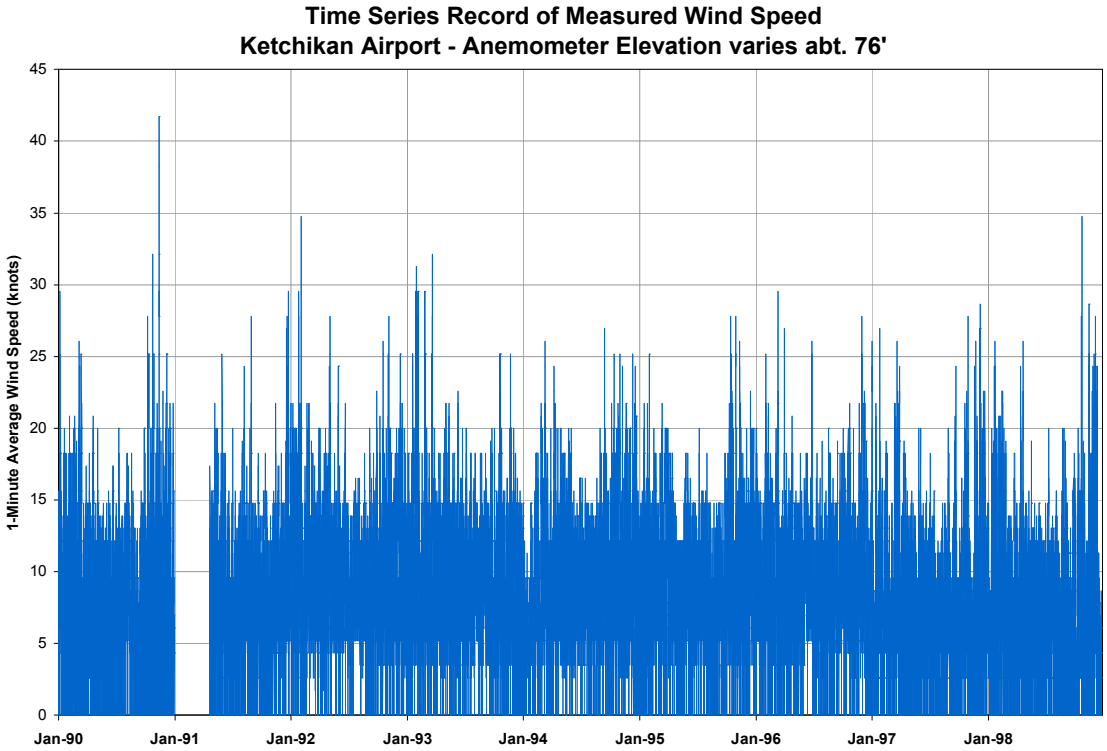


Figure 1

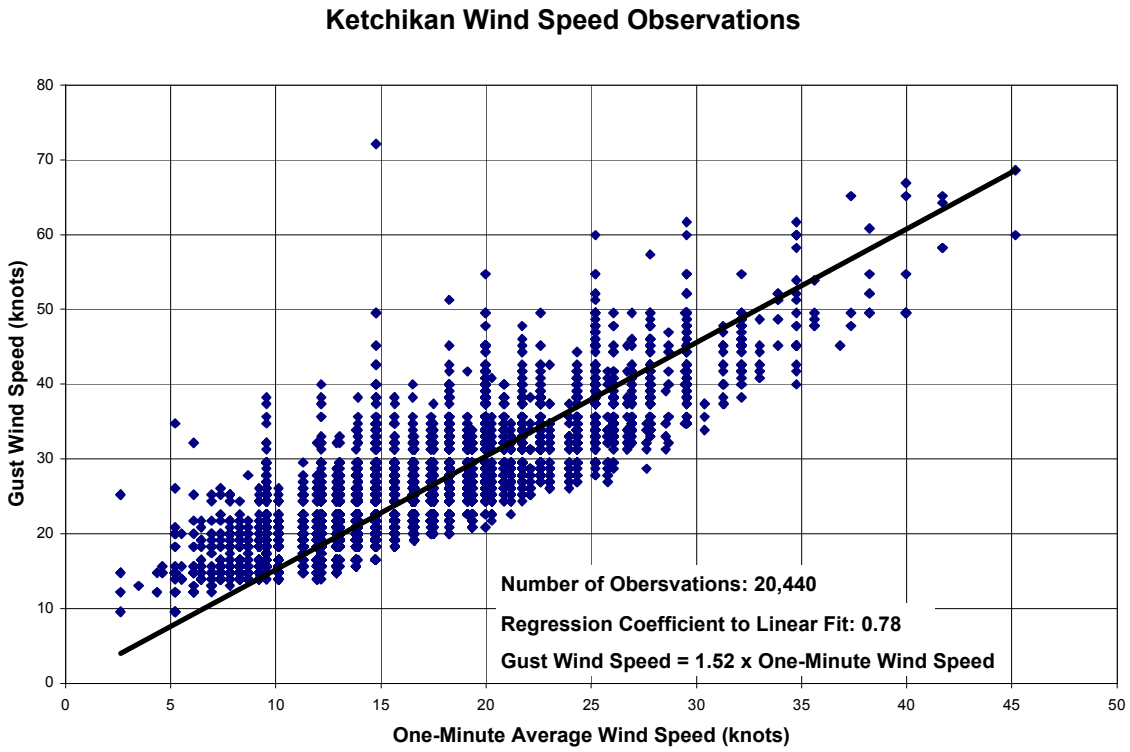


Figure 2

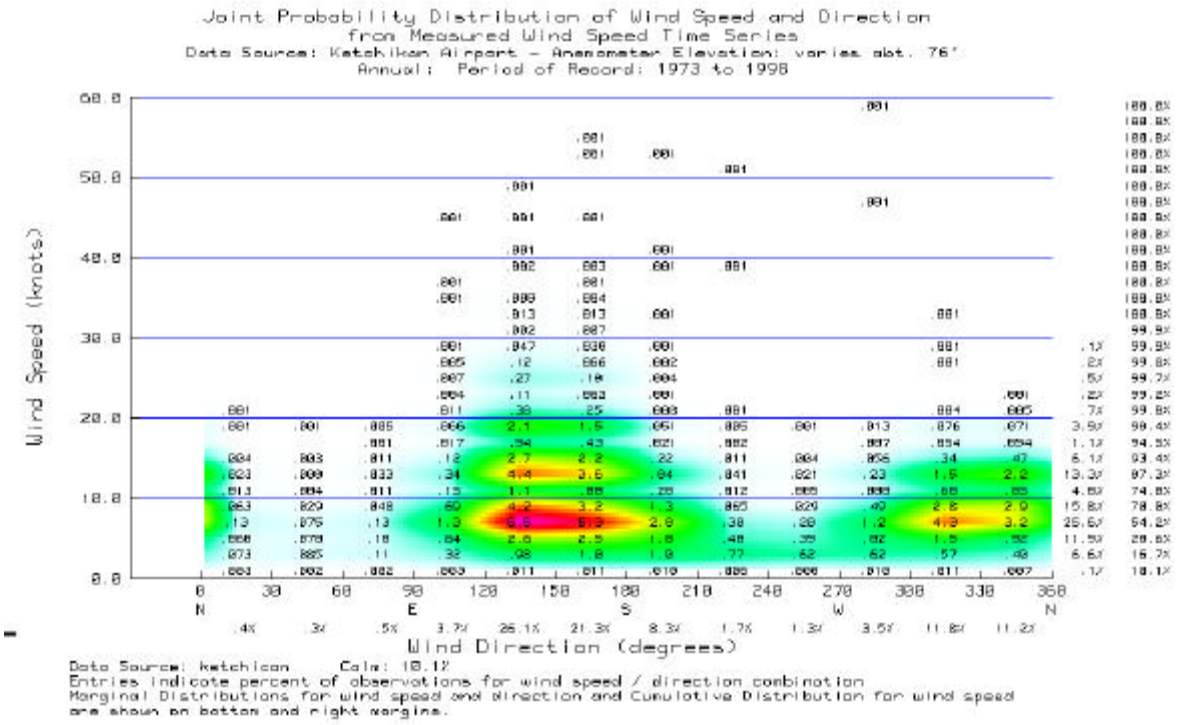


Figure 3

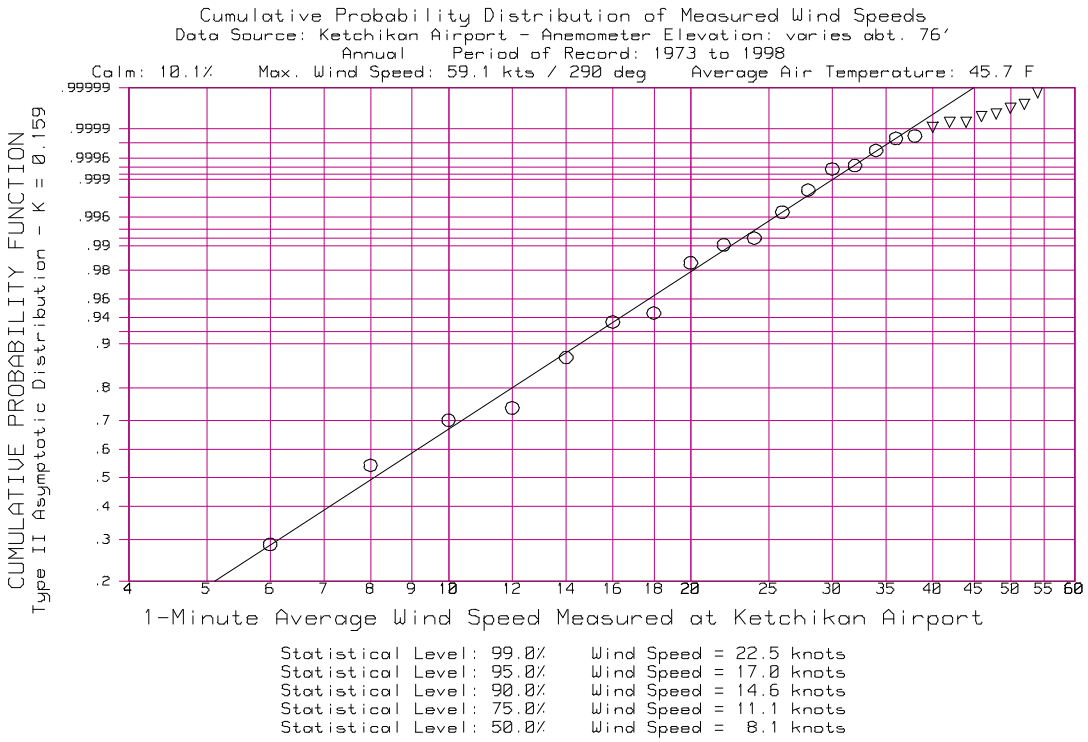
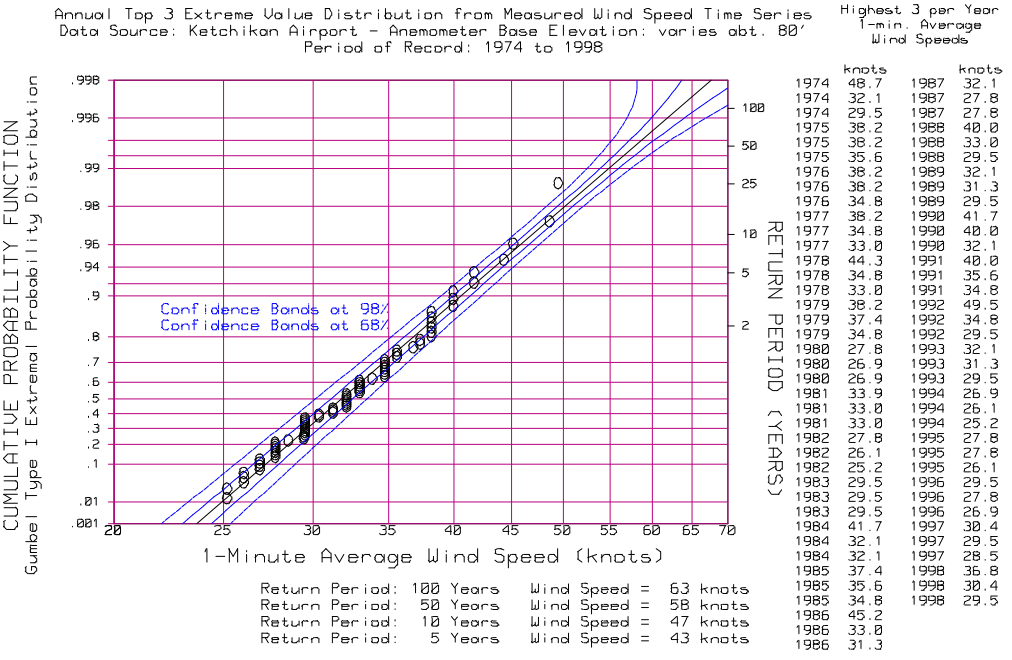


Figure 4



	knots		knots
1974	48.7	1987	32.1
1974	32.1	1987	27.8
1974	29.5	1987	27.8
1975	38.2	1988	40.0
1975	38.2	1988	33.0
1975	35.6	1988	29.5
1976	38.2	1989	32.1
1976	38.2	1989	31.3
1976	34.8	1989	29.5
1977	38.2	1990	41.7
1977	34.8	1990	40.0
1977	33.0	1990	32.1
1978	44.3	1991	40.0
1978	34.8	1991	35.6
1978	33.0	1991	34.8
1979	38.2	1992	49.5
1979	37.4	1992	34.8
1979	34.8	1992	29.5
1980	27.8	1993	32.1
1980	26.9	1993	31.3
1980	26.9	1993	29.5
1981	33.9	1994	26.9
1981	33.0	1994	26.1
1981	33.0	1994	25.2
1982	27.8	1995	27.8
1982	26.1	1995	27.8
1982	25.2	1995	26.1
1983	29.5	1996	29.5
1983	29.5	1996	27.8
1983	29.5	1996	26.9
1984	41.7	1997	30.4
1984	32.1	1997	29.5
1984	32.1	1997	28.5
1985	37.4	1998	35.8
1985	35.6	1998	30.4
1985	34.8	1998	29.5
1986	45.2		
1986	33.0		
1986	31.3		

Figure 5

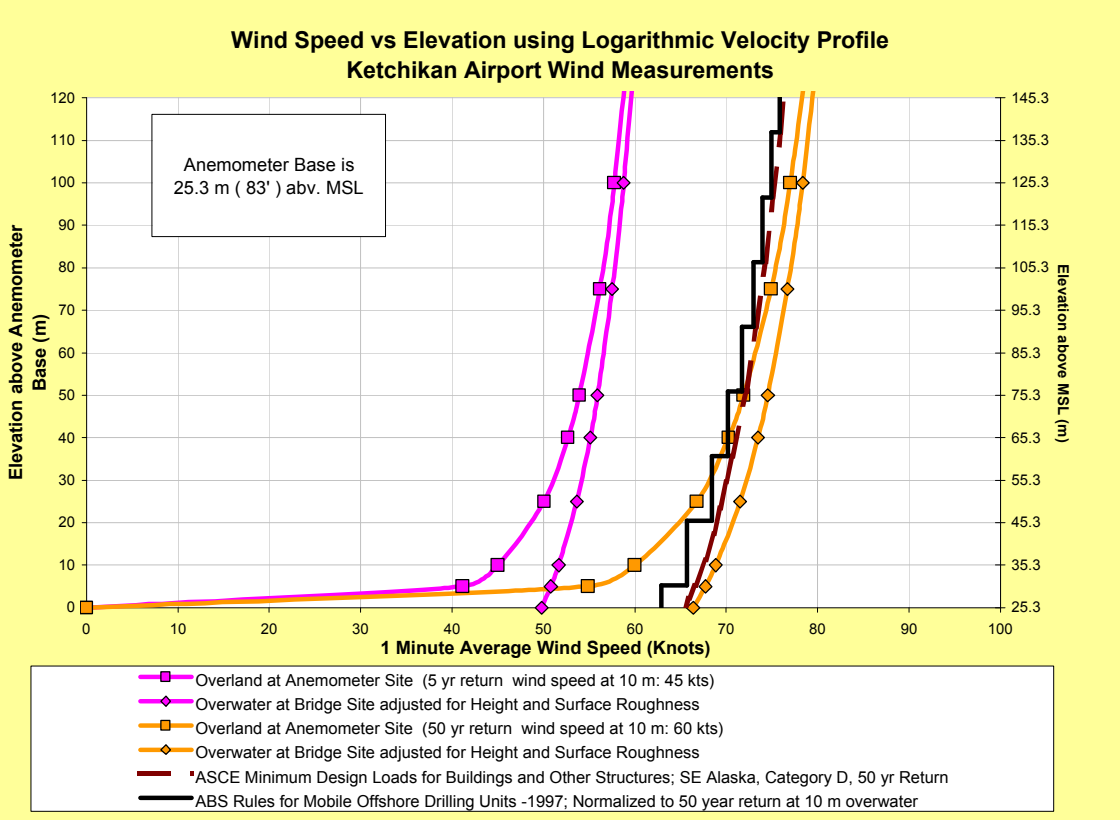


Figure 6

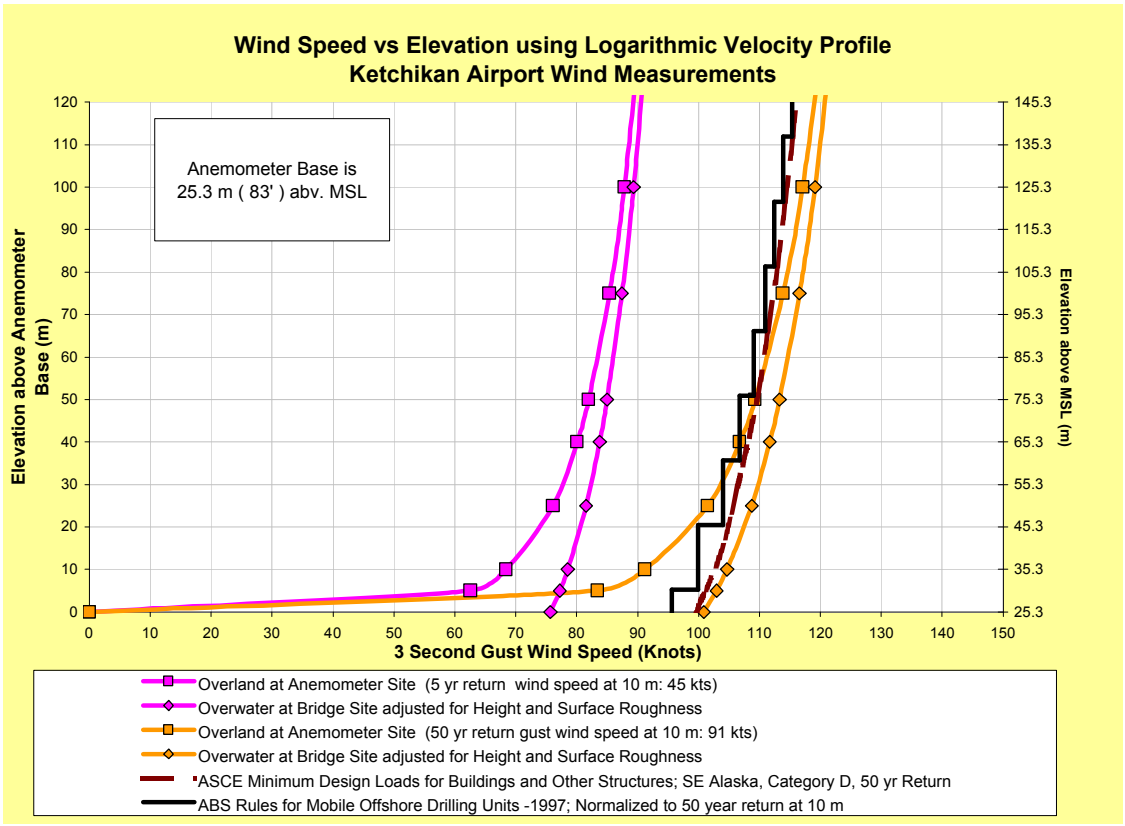


Figure 7

Table 2

Statistical Level:	99th Percentile	95th Percentile	90th Percentile	75th Percentile	50th Percentile
January					
Wind Speed (kts):	23.7	18.4	15.8	12.0	8.2
February					
Wind Speed (kts):	24.3	18.7	16.1	12.2	8.6
March					
Wind Speed (kts):	23.0	17.1	14.6	11.2	8.3
April					
Wind Speed (kts):	21.4	17.0	14.9	11.7	8.6
May					
Wind Speed (kts):	20.1	15.8	13.9	11.0	8.3
June					
Wind Speed (kts):	18.6	14.3	12.5	10.1	8.1
July					
Wind Speed (kts):	17.3	13.9	12.3	10.0	7.8
August					
Wind Speed (kts):	18.2	14.4	12.6	10.1	7.8
September					
Wind Speed (kts):	20.5	15.1	13.0	10.1	7.8
October					
Wind Speed (kts):	23.8	18.2	15.6	11.8	8.3
November					
Wind Speed (kts):	25.8	18.6	15.6	11.5	8.1
December					
Wind Speed (kts):	23.6	18.2	15.6	11.8	8.2
Annual					
Wind Speed (kts):	22.5	17.0	14.6	11.1	8.1

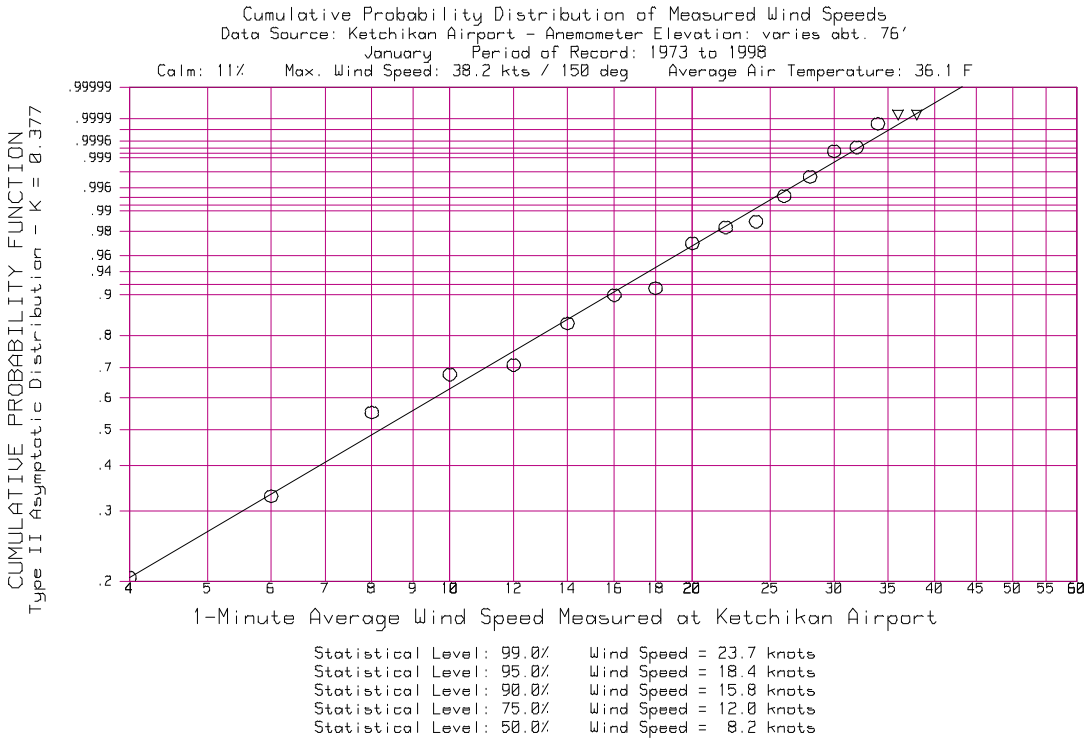


Figure 8

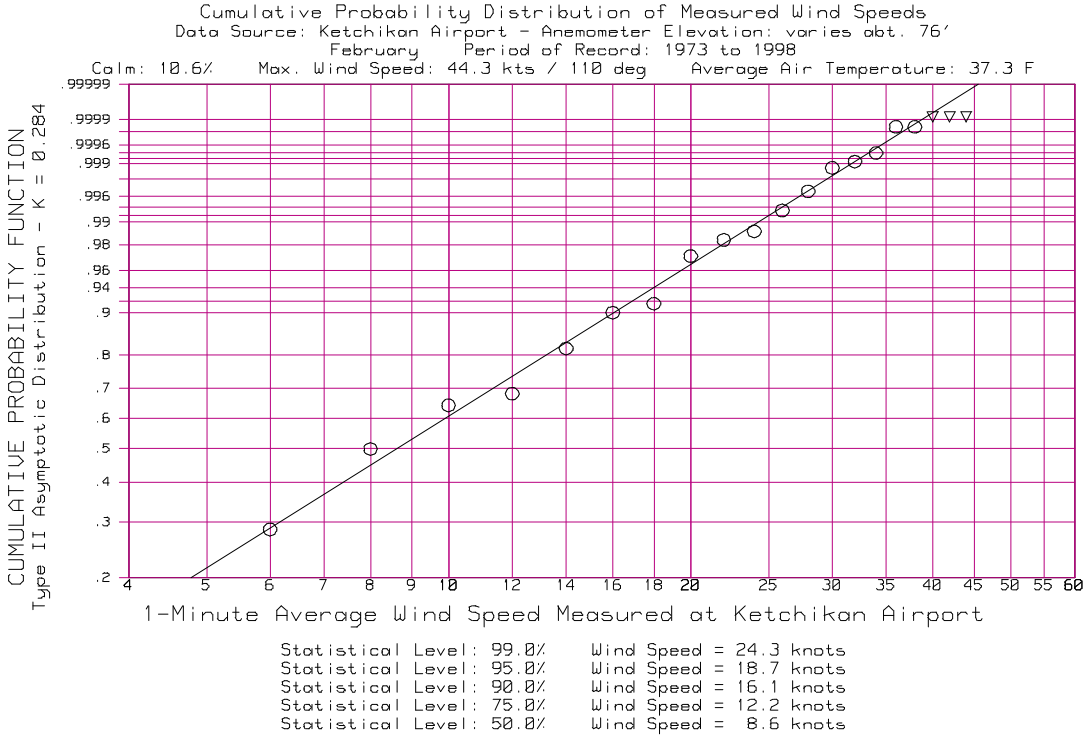


Figure 9

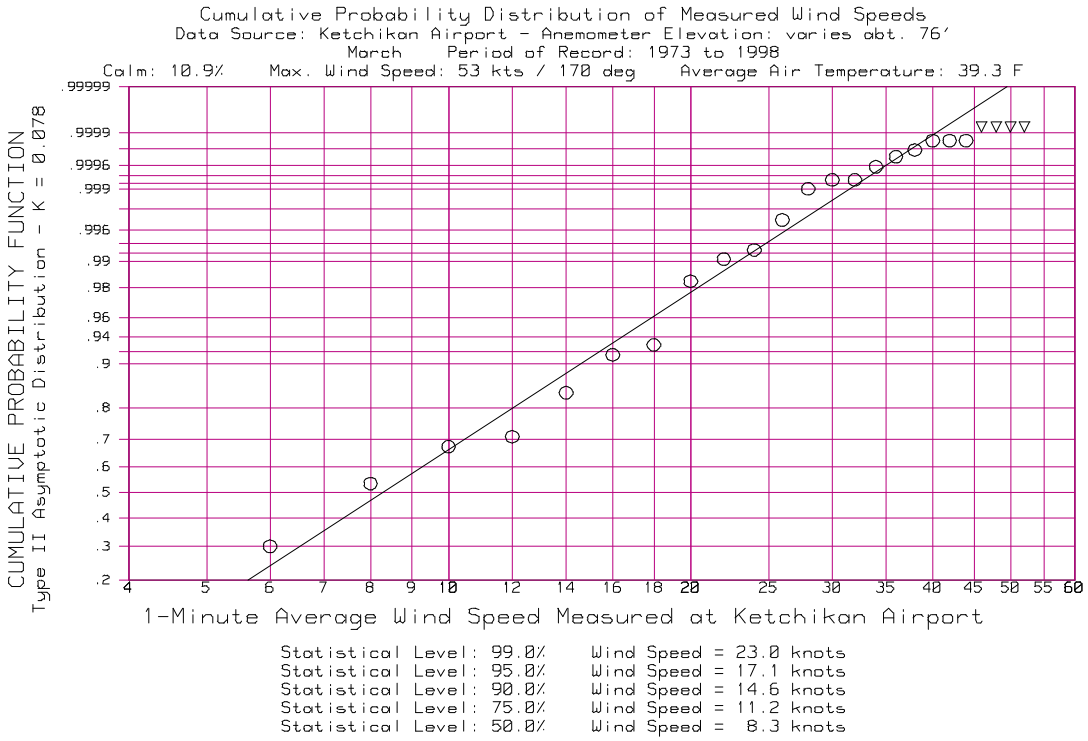
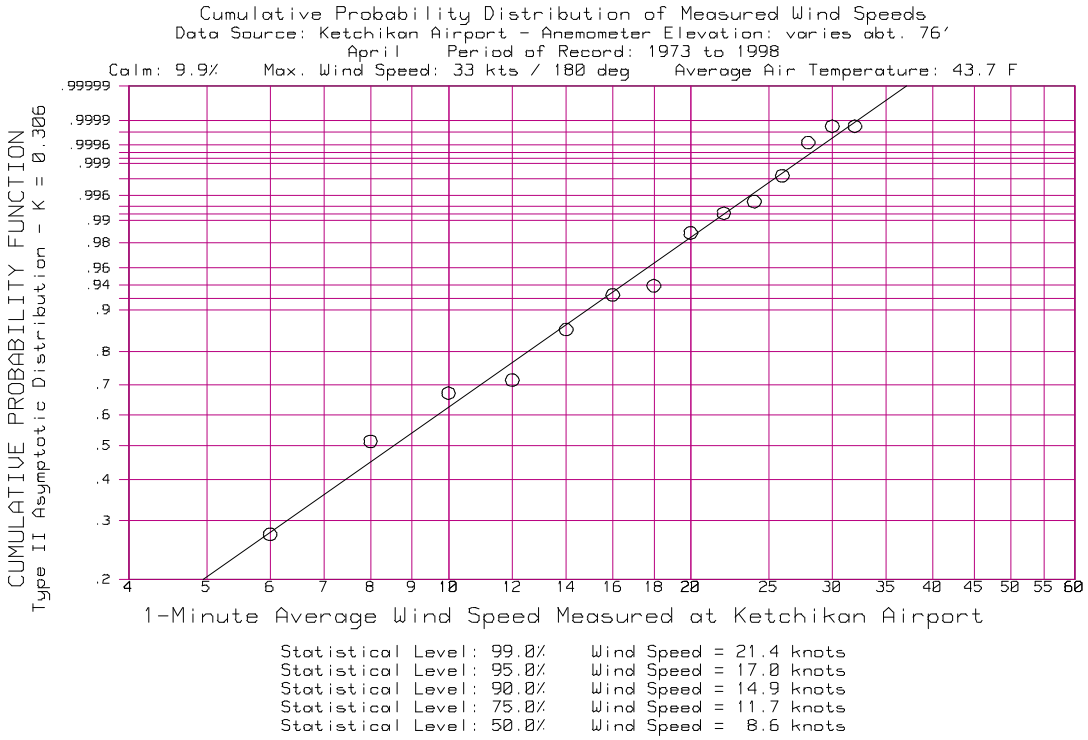


Figure 10



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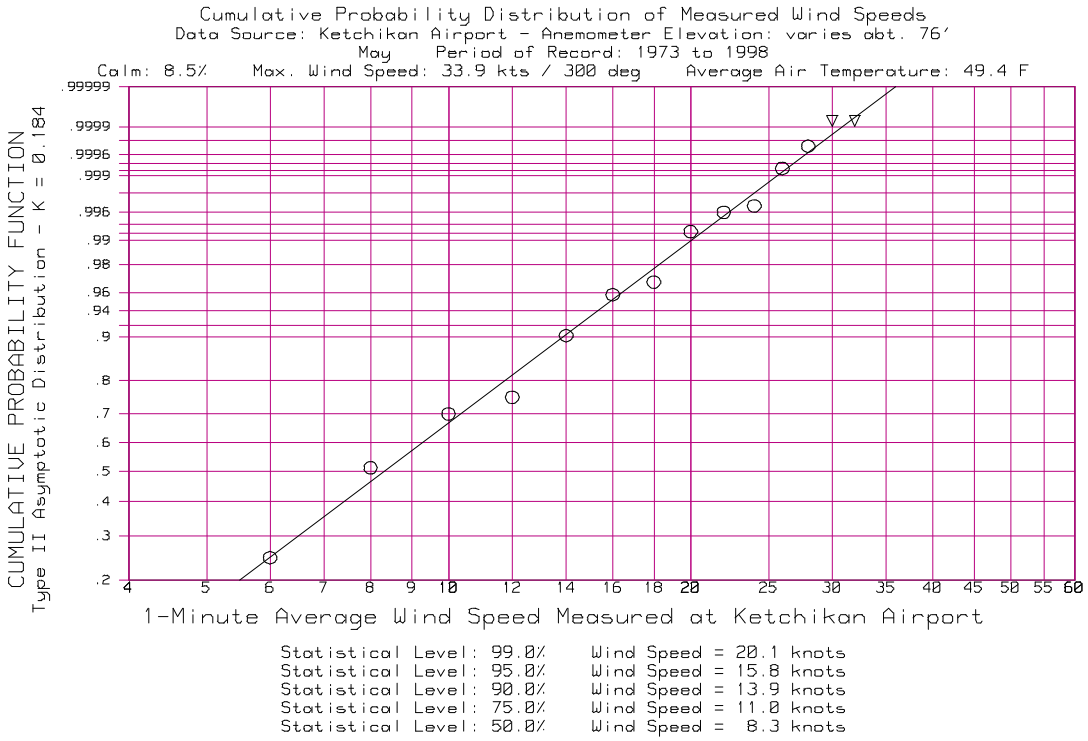

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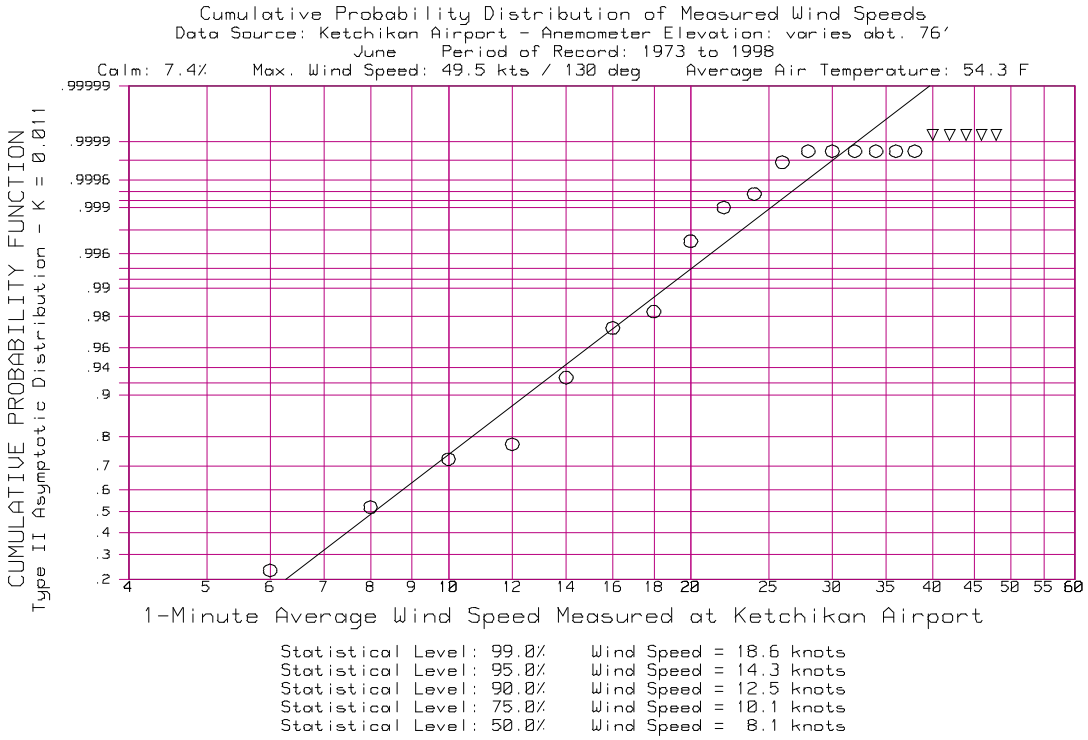
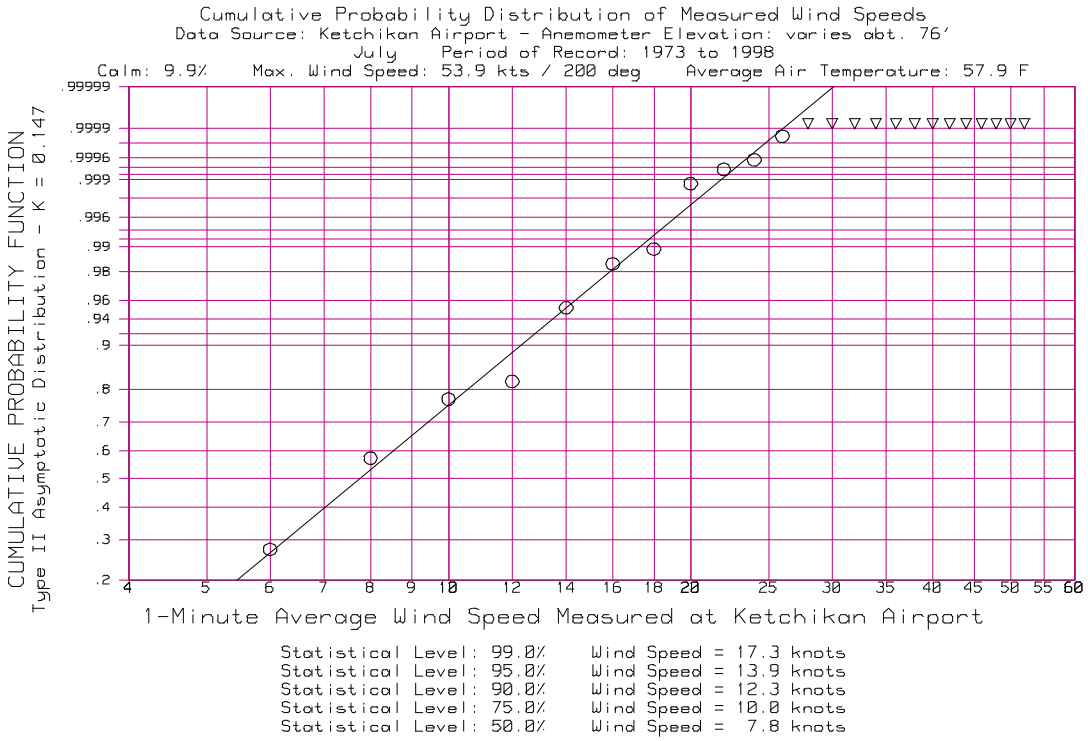


Figure 13



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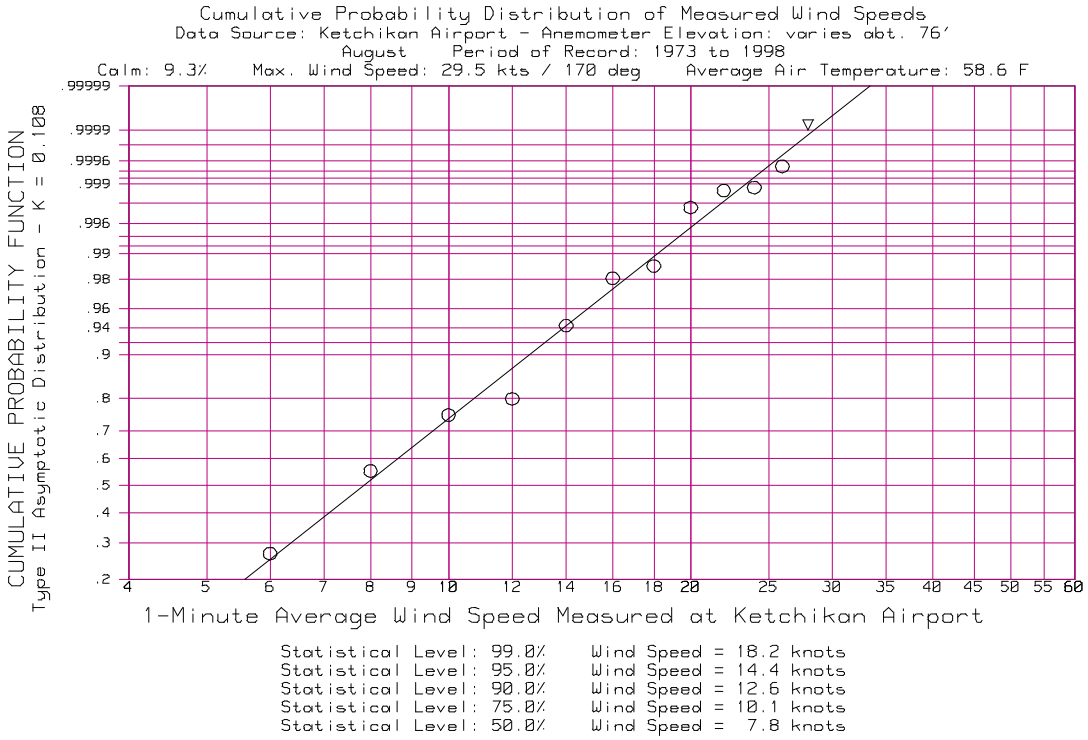

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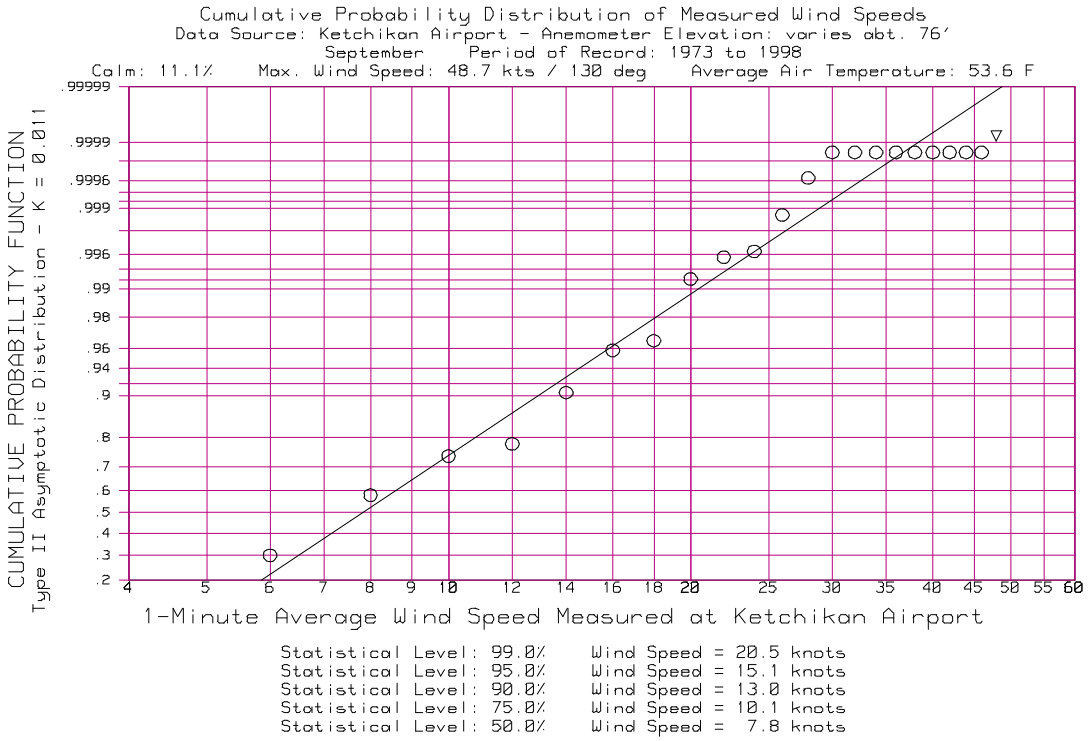
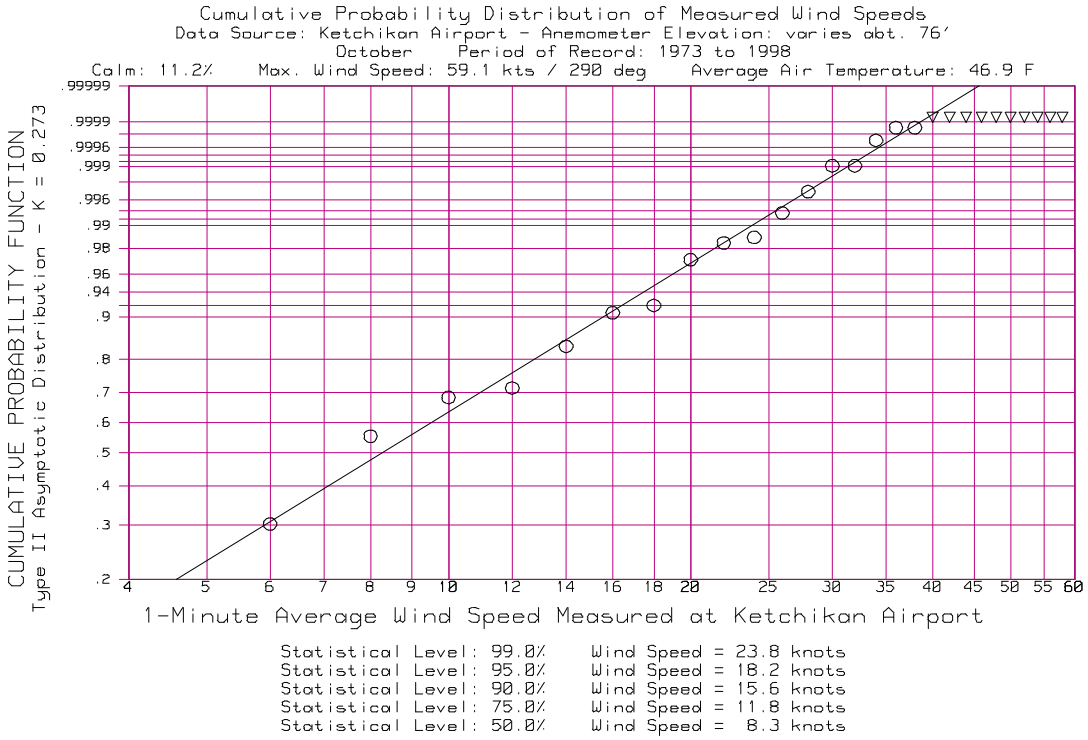


Figure 16



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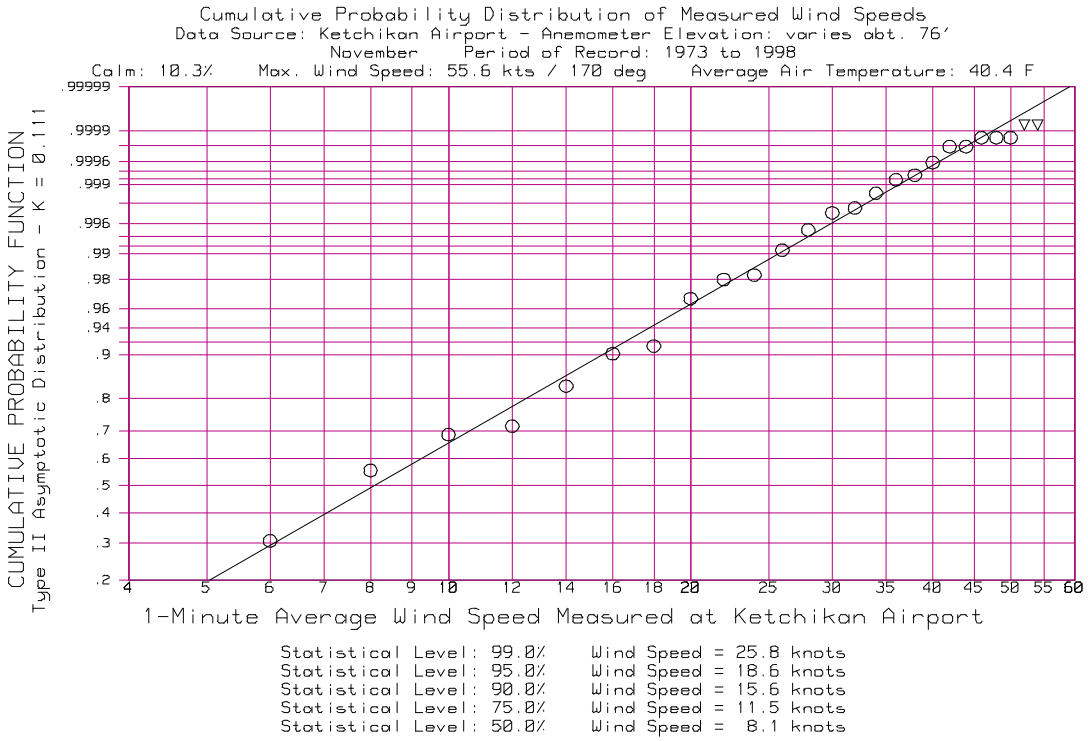

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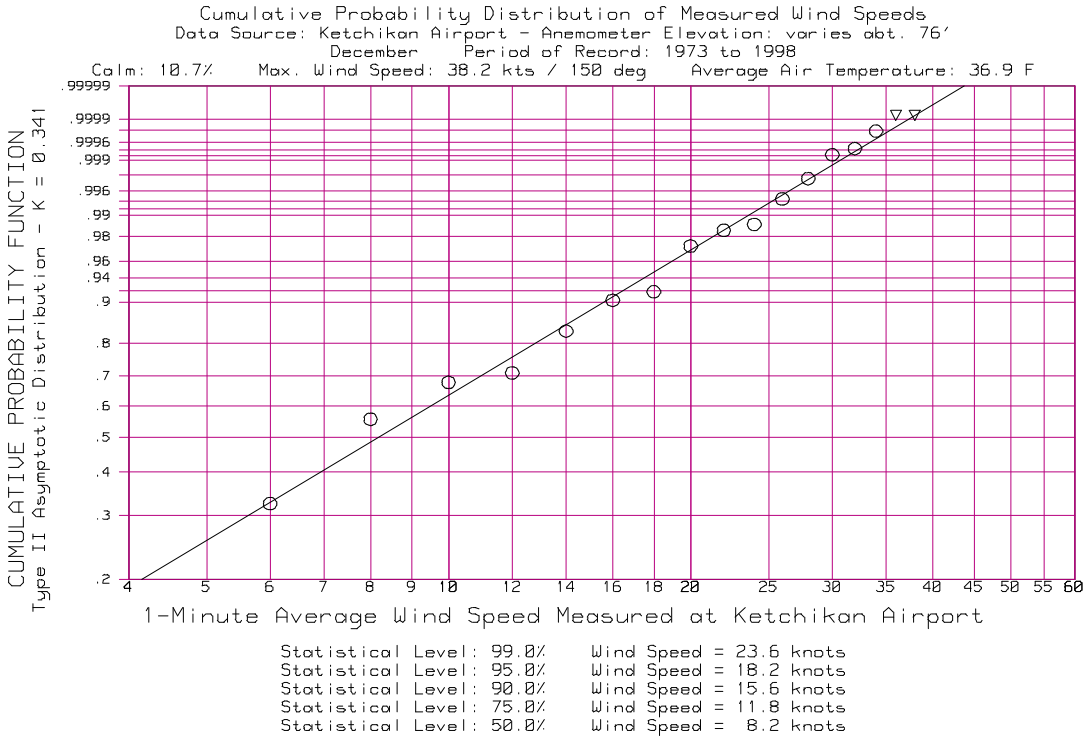

Figure 19